DIFFUSER DESIGN
FOR
CYPRUS THOMPSON CREEK

Prepared for:

Cyprus Thompson Creek Mine
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1.0 INTRODUCTION

Steffen Robertson and Kirsten Inc. (SRK) has modelled five options for a diffuser configuration for the proposed Cyprus - Thompson Creek Mine outfall to the Salmon River. Options studied range from an open-ended pipe (single port) configuration to a 16-port, 16-meter long diffuser that would span approximately half the width of the river at 7-year,10-day low streamflow conditions. Assumptions and methods used in the analysis and results are explained below.

2.0 DESIGN APPROACH

Basic assumptions used to complete the analysis were as follows:

1. Streamflow in the Salmon River below Thompson Creek, the diffuser location, was estimated using the U.S.D.I. Geological Survey gage on the Salmon River immediately below Yankee Fork. Streamflow at 7-day 10-year low conditions in the Salmon River below Thompson Creek was calculated to be 323 cubic feet per second (cfs) and the mean annual flow was calculated to be 1,240 cfs. The U.S.D.I. Geological Survey supplied a computer analysis of streamflow characteristics for the gage number 13296500, Salmon River below Yankee Fork near Clayton, Idaho. The calculated 7-year, 10-day low streamflow rate for the gage was multiplied by the drainage basin ratio between the gage and diffuser location to obtain the 7-day, 10-year low streamflow rate for the diffuser location. Mean annual flow at the diffuser location was also obtained using the drainage basin ratio.

2. The U.S. Army Corp of Engineers computer program HEC-2 was used to obtain the depth and velocity of flow in the Salmon River at the diffuser location for all streamflow rates analyzed. Surveyed cross sections provided by Cyprus - Thompson Creek were used to characterize channel geometry. Observations made during the August, 1993 site survey by SRK were used to determine roughness of the streambed.

3. The following assumptions were made concerning the diffuser:

    - The diffuser would consist of a buried pipe with risers 4 to 6-inches in height above the stream bed.
    - Water depth was at least one foot at port locations.
    - Initially the ports were assumed to have a discharge angle of 60 degrees from the streambed and point downstream. The final design used a 90 degree discharge angle.
    - Minimum discharge velocity from a port is 10 feet per second at the average discharge rate of 2.5 cfs.
    - The diffuser is located according to the geometry of the north bank of the river.

4. The following assumptions were made concerning the Cyprus - Thompson Creek outfall discharge:

- An average discharge flow rate of 2.5 cfs was modelled.
- Minimum and maximum discharge rates of 1.0 and 4.0 cfs, respectively, were also used to determine the port sizes and head requirements.
- The discharge was assumed to have the same density as the ambient river water.
- When streamflow in the Salmon River is at the 7-day 10 year low flow rate (323 cfs), the total available dilution would be 129 for a effluent discharge rate of 2.5 cfs.
- When streamflow in the Salmon River equals the mean annual flow rate (1240 cfs), the total available dilution is 496 for an effluent discharge rate of 2.5 cfs.

3.0 MIXING ZONE ANALYSIS

Diffuser performance and mixing in the Salmon River and was modelled with the U.S. Environmental Protection Agency computer programs CORMIX1 (single port) and CORMIX2 (multiple port). Results of the initial modelling effort are found in Tables 1 and 2 and Figure 1. As seen in Table 1, five diffuser configurations were initially reviewed including a simple open-ended pipe and a 16-port, 16 meter long diffuser. Key diffuser characteristics are also given in Tables 1 and 2.

Mixing in the Salmon River downstream of the Cyprus - Thompson Creek outfall could be due to three mechanisms: 1) Jet momentum as water exits the discharge port; 2) Buoyancy; and 3) Ambient mixing resulting from natural currents or turbulence in the river. In this case, the density of the discharge is assumed equivalent to the river water. Therefore, buoyancy is not a factor in the mixing zone calculations.

The CORMIX hydrodynamic mixing zone models calculate mixing in two regions relative to the diffuser location. The first region is called the near field, and typically is an area in the first 10 to 30 feet downstream of the diffuser. For the Cyprus - Thompson Creek discharge, near field mixing will be driven by the interaction between the high velocity jet leaving the discharge port and the ambient river water. Rapid initial mixing occurs when energy of the water in the jet dissipates as it exits a discharge port. The jet energy is soon dissipated, however, and near field mixing therefore occurs relatively close to the diffuser.

Once the discharge jet has dissipated the region of the far field begins. This would occur at a distance of approximately 30 feet downstream of the diffuser in this case. Far field mixing occurs as the result of natural currents and turbulence in the river.

The CORMIX models calculate the dilution rate along the centerline of the discharge plume. For example, in Table 1, a 5-port 16-foot long diffuser results in a dilution of 24 times at a point 0.3 feet downstream of the diffuser. This means the effluent discharged from the diffuser has been diluted by a factor of 24 by the time the effluent would reach a distance 0.3 feet from the diffuser. In comparison, at a 7-day, 10-year recurrence low flow rate in the Salmon River (323 cfs), the total dilution available for a 2.5 cfs discharge would be 129.

TABLE 1: Centerline Dilution at Given Distances[1] (7-year, 10-day low flow)[2]

		1-port	3-port	5-port	8-port	16-port
Diffuser length (feet)		-	10	16	26	52
Port diameter (inches)		6.5	3.75	3	2.25	1.5
	Downstream Distance (feet)					
Near Field	0.3	1.1	11	24	42	82
	0.6	1.2	11	24	42	82
	1.5	2.1	11	24	42	82
Far Field	98	9.7	14	26		65
	115				36	
	197	13.5		29	39	66
	328				42	69
	393	19	22	36	45	70
	689	25	27	44	52	75
	984	30	32	50	59	80
	1639	39	40	63	71	89
	3279	55	56	85	94	109
	4918	67	68	104	113	115

NOTES:

(1) Dilution provided in the center of the discharge plume.

(2) Total available dilution is 129, the ratio of the streamflow rate of 323 cfs to the discharge rate of 2.5 cfs.

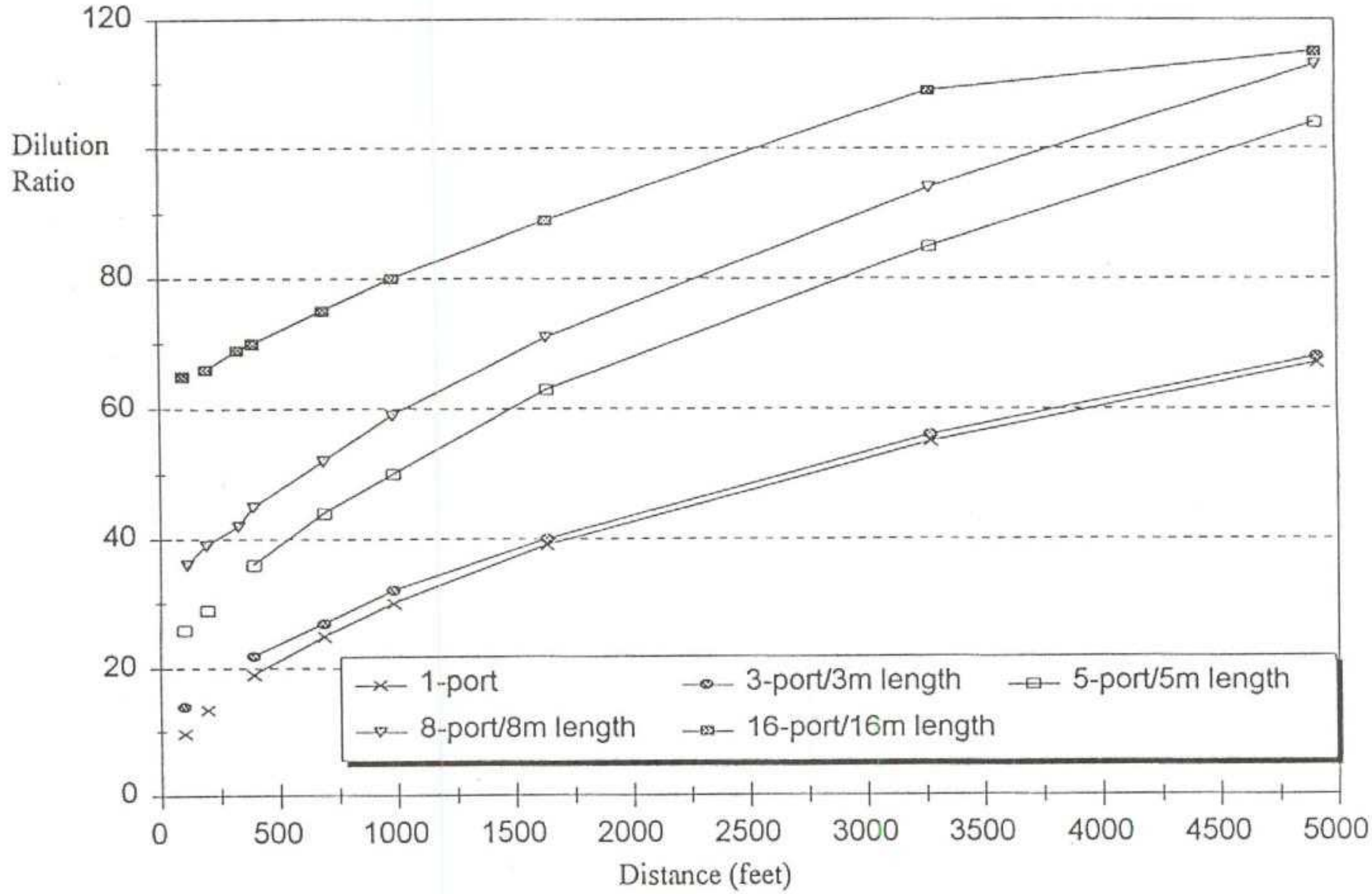
TABLE 2: Centerline Dilution at Given Distances[1] (mean annual flow rate)[2]

		1-port	8-port
Diffuser length (feet)		-	26
Port diameter (inches)		6.5	2.25
	Downstream Distance (feet)		
Near Field	0.3	1.1	120
	0.6	1.4	120
	1.5	1.5	120
Far Field	98	98	111
	115	79	125
	197	98	130
	328	126	154
	393	138	166
	689	178	200
	984	195	216
	1639	252	270
	3279	356	368
	4918	408	446

NOTES:

(1) Dilution provided in the center of the discharge plume.

(2) Total available dilution is 496, the ratio of the streamflow rate of 1,240 cfs to the discharge rate of 2.5 cfs.



Steffen Robertson and Kirsten
Consulting Engineers and Scientists

PROJECT	00945-Cyprus Thompson Creek
FIGURE 1	Low Flow Diffuser Analysis Far Field Dilution vs Distance
DATE	November 1993

Model results for the Cyprus - Thompson Creek outfall for low-flow conditions show rapid and complete mixing vertically in the water column occurring very close to the diffuser. The extent of mixing during low-flow conditions appears to be directly proportional to the number of discharge ports and diffuser length. Compared to multiple port diffusers, the single port configuration performs poorly in the near field. A diffuser length approximately half the width of the stream (52 feet) allows approximately half the available dilution to occur in the near field. A diffuser length approximately one fourth the width of the river (26 feet) allows approximately one third the available dilution to occur in the near field. Even at a streamflow rate equal to the mean annual flow value, a single port diffuser provides no significant near field dilution (Table 2).

As previously explained, mixing in the far field is primarily the result of natural currents and turbulence in the river. A 26-foot long diffuser will allow approximately half the available dilution to occur during low flow conditions within 1,000 feet of the outfall. Compared to a 26-foot long diffuser, approximately one third more dilution would occur during low flow conditions at a point 1,000 feet below the outfall if a 52-foot long diffuser were installed. A single port diffuser would allow approximately half the available dilution to occur during low flow conditions at a distance greater than one mile downstream of the outfall.

Based on field observations at the site, there are at least three points when the main current of the river would shift from the south to north sides of the river, or vice versa, within approximately 2,000 feet of the bridge. This characteristic would result in an underestimation of dilution at these distances by the EPA models. In fact, the first current shift occurs approximately 500 to 600 feet downstream of the bridge. SRK would expect the dilution provided by 20 to 50-foot long diffusers would more comparable in magnitude than predicted by the EPA model below this first current shift.

4.0 DIFFUSER SIZE SELECTION

A final design for the diffuser was chosen by refining the initial model results and through consideration of State of Idaho mixing zone requirements. For the Cyprus - Thompson Creek outfall, the State of Idaho mixing zone requirements have the following constraints that apply:

1. The width of the mixing zone is not to exceed 25 percent of the stream width.

2. The mixing zone is to be no closer to the 10-year 7-day low flow shoreline than 15 percent of the stream width.

3. The mixing zone is not to include more than 25 percent of the volume of the streamflow. In this case, this constraint means the maximum dilution which can be provided within the mixing zone is 32, or one quarter of the dilution available in the river at the design streamflow.

Based on the initial mixing zone model results reported in Tables 1 and 2, Figure 1, and considering the Idaho mixing zone requirements, a final diffuser design was chosen. The diffuser consists of 5-ports, the ports are three inches in diameter and the diffuser is 20 feet long (see Figure 2). Output from the CORMIX2 program which shows the mixing provided by this diffuser is found in Appendix A. The reasons for selecting these characteristics are as follows:

- The chosen design provides the maximum allowable dilution according to the Idaho requirements within 10 feet of the diffuser. Model results show the mixing zone size to be 8.2 feet long in a downstream direction from the diffuser and 20 feet wide (the diffuser length) at design flow conditions. In addition to providing rapid initial dilution, the chosen design provides a relatively short diffuser manifold and minimizes the number of ports to ease construction and maintenance requirements.

- A single port diffuser provides significantly less dilution than the proposed diffuser.

- A longer diffuser does provide more initial dilution but would require significantly more disturbance of the river bed to install and would be significantly more difficult to maintain. Furthermore, within approximately 1,000 feet of the outfall the additional dilution provided by a longer diffuser would become insignificant.

5.0 DIFFUSER DESIGN CRITERIA

The design for the diffuser is shown on Figure 2. HPDE pipe has been specified because it should ease construction and maintenance of the diffuser. Ports are attached to the diffuser pipe with flanges to ease repairs. The diffuser pipe ends with a blind flange which can be removed to clean the pipe. Weight size and spacing has been determined from guidelines provided by the manufacturer.

A break pressure and equalization tank will need to be constructed near the pump house to eliminate high pressures which will occur in the discharge pipeline near the pumphouse and to provide the hydraulic head needed to allow the diffuser to function as designed. A float actuated valve at the inlet of the tank would be used to regulate the discharge rate to the Salmon River and the hydraulic head provided by the tank. A concrete tank approximately 12 feet wide, 20 feet long and 8 feet deep would be required.

The hydraulic head needed to provide the desired discharge rates has been calculated according to the method developed by Rawn et al, 1961. A spreadsheet was used to make the necessary calculations and pertinent printouts are found in Appendix B. The limiting condition will occur when the mine wants to discharge 4 cfs during relatively high streamflow conditions. The water surface elevation during the 2.33 year flood has been used to determine the maximum hydraulic head needed for the diffuser to function as designed during high-flow conditions.

Table 3 presents required hydraulic head conditions for several effluent discharge rates and streamflow conditions. Depth and elevation of water in the break pressure tank needed to provide the required hydraulic head is also specified in Table 3.

TABLE 3: Diffuser Hydraulic Head Requirements[1]

Streamflow Rate (cfs)	Streamflow Condition	Discharge Rate (cfs)	Required Head (ft)[1]	Minimum Water Surface Elevation Required (ft)[2]	Minimum Depth in Break Pressure Tank (ft)[3]
5040	2.33 yr flood	4	10.55	5,589.3	7.15
4040	mean monthly flow for June	4	10.55	5,588.75	6.6
323	7Q10 Lowflow	4	10.55	5,584.52	2
323	7Q10 Lowflow	2.5	4.13	5,578.1	<1

NOTES:

(1) Necessary minimum hydraulic head for diffuser to function as designed.

(2) Minimum water surface elevation needed in break pressure tank to meet required hydraulic head.

(3) Minimum depth in break pressure tank to meet required hydraulic head.

6.0 MONITORING AND MAINTENANCE

The condition and performance of the diffuser will need to be monitored on a regular basis to ensure that the design capacity is maintained. The diffuser pipe should be visually inspected regularly during active periods of discharge on a schedule consistent with the NPDES permit.

Inspection of the diffuser should include a visual examination of the following items:

- Check the overall integrity of visible parts of the diffuser for damage or signs of severe stress.
- Check for flow obstructions.
- Check the adjacent channel bed for evidence of scour.
- Check the visual performance of the system and compare with recorded observations to determine if a deficiency is apparent.

If a deficiency is detected in any of the items listed above, maintenance measures would be implemented immediately to correct the problem.

The flanged design of the diffuser facilitates the maintenance process should removal and cleanout of the pipe be required. In the unlikely event of external damage to the pipe or internal clogging, the pipe would be uncovered, opened at the flange and repaired, replaced, or thoroughly cleaned out, as necessary.

In addition to the scheduled inspections, the diffuser would be examined carefully after extreme flood events and during the freeze and thaw seasons. The appropriate maintenance measures would then be implemented as necessary.

Monitoring of the diffuser pipe should also include inspection of the creek bottom around the discharge ports for evidence of scour. In the unlikely event that significant scour occurs, remedial channel stabilization measures would be implemented. Such measures may include the use of concrete and/or larger riprap for channel bottom stabilization.

7.0 CONCLUSION

This document presents a diffuser design which provide significant dilution in a small mixing zone and allows discharge of 1 to 4 cfs of effluent to the Salmon River. Dimensions of the diffuser have been specified according to the average discharge rate of 2.5 cfs, 7-day 10-year low flow conditions in the Salmon River and State of Idaho mixing zone requirements.

Reference: Rawn, A.M., Bowerman, F.R., and Brooks, N.H., 1961, Diffusers for disposal of sewage in sea water. Trans. Am. Soc. Civil Eng. 126, Part III, pg 344-388.

APPENDIX A
CORMIX2 Results for Final Design Diffuser

Diffuser Length = 20 feet
Port Diameter = 3 inches
Port Spacing = 5 feet
Discharge Rate = 2.5 cfs
Streamflow Rate = 323 cfs

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                        CORNELL MIXING ZONE EXPERT SYSTEM
CORMIX2: Submerged Multiport Diffusers        EPA Version 1.30 (February 1992)

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CASE DESCRIPTION
 SITE NAME:             Thompson Creek
 DISCHARGER NAME:       Cyprus
 POLLUTANT NAME:        x

 DESIGN CASE:           5port 3inch 20feet
 DOS FILE NAME:         cmx2   .CXO
 DATE AND TIME OF FORTRAN SIMULATION:   11-11-1993_ 9:57:41

ENVIRONMENT PARAMETERS (METRIC UNITS)
 BOUNDED SECTION
 BS    =     33.50  AS     =     12.73  QA     =      9.15
 HA    =      0.38  HD     =      0.49
 UA    =      0.719 F      =      0.239

 UNIFORM DENSITY ENVIRONMENT
 RHOA  =   1000.00

DIFFUSER DISCHARGE PARAMETERS (METRIC UNITS)
 DITYPE = unidirectional_perpendicular
 BETYPE = unidirectional_without_fanning
 BANK   = LEFT      DISTB  =     14.05  YB1    =     11.00  YB2    =     17.10
 LD     =      6.10  NOPEN  =   5        SPAC   =      1.52
 D0     =      0.076 A0     =      0.005 H0     =      0.15
 GAMMA  =     90.00  THETA0 =      0.00
 SIGMA  =      0.00  BETA   =     90.00
 (ALPHA =      0.00  DELTA  =      0.00)
 U0     =      3.131 Q0     =      0.071 (Q0    =0.7100E-01)
 RHO0   =   1000.00  DRHO0  =      0.00  GP0    =0.0000E+00
 C0     =0.1000E+03  UNITS  = percent

FLUX VARIABLES - PER UNIT DIFFUSER LENGTH
 q0     =0.1164E-01  m0     =0.3644E-01  j0     =0.0000E+00  SIGNJ0 = 1.
 ASSOCIATED 2-D LENGTH SCALES (METERS)
 lq=B   =      0.004 lM     =  99999.90  lm     =      0.07
 lmp    =  99999.90  lbp    =  99999.90  la     =  99999.90

FLUX VARIABLES - ENTIRE DIFFUSER
 Q0     =0.7100E-01  M0     =0.2223E+00  J0     =0.0000E+00
 ASSOCIATED 3-D LENGTH SCALES (METERS)
 Lq     =      0.15  LM     =  99999.90  Lm     =      0.66  Lb     =      0.00
                                         Lmp    =  99999.90  Lbp    =  99999.90

NON-DIMENSIONAL PARAMETERS
 FR0    =  99999.90  FRD0   =  99999.90  R      =      4.35
 (SLOT)              (PORT/NOZZLE)

FLOW CLASSIFICATION
 ****************************************************************
 *        FLOW CLASS                       =      MU2           *
 *        APPLICABLE LAYER DEPTH HS        =      0.49          *
 ****************************************************************
```

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS

```
C0     =0.1000E+03  CUNITS = percent
NSTD   =  0         CSTD.  =0.1000E+07
LEGMZ  =  0         LEGSPC =  0          LEGVAL =  99999.90
XLEG   =       0.00 WLEG   =       0.00  ALEG   =       0.00
XINT   =    1500.00
XMAX   =    1500.00
NSTEP  = 50
```

X-Y-Z COORDINATE SYSTEM:

ORIGIN is located at the bottom and the diffuser mid-point:

14.05 m from the LEFT bank/shore.

X-axis points downstream, Y-axis points to left, Z-axis points upward.

BEGIN MOD201: DISCHARGE MODULE

PROFILE DEFINITIONS:

BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory

BH = top-hat half-width, in horizontal plane normal to trajectory

C = centerline concentration

S = corresponding centerline dilution

PREDICTION

X	Y	Z	S	C	BV	BH
0.00	0.00	0.15	1.0	0.100E+03	0.00	3.05

END OF MOD201: DISCHARGE MODULE

BEGIN MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

IN THIS ZONE THE DIFFUSER PLUME BECOMES VERTICALLY FULLY MIXED

OVER THE ENTIRE LAYER DEPTH (HS = 0.49m).

FULL MIXING IS ACHIEVED AFTER A PLUME DISTANCE OF ABOUT FIVE

LAYER DEPTHS FROM THE DIFFUSER.

PROFILE DEFINITIONS:

BV = layer depth (vertically mixed)

BH = top-hat half-width, in horizontal plane normal to trajectory

C = average (bulk) concentration

S = corresponding average (bulk) dilution

PREDICTION

X	Y	Z	S	C	BV	BH
0.00	0.00	0.49	1.0	0.100E+03	0.49	3.05
0.06	0.00	0.49	32.3	0.310E+01	0.49	3.04
0.12	0.00	0.49	32.3	0.310E+01	0.49	3.03
0.18	0.00	0.49	32.3	0.310E+01	0.49	3.02
0.24	0.00	0.49	32.3	0.310E+01	0.49	3.01
0.31	0.00	0.49	32.3	0.310E+01	0.49	3.00
0.37	0.00	0.49	32.3	0.310E+01	0.49	3.00
0.43	0.00	0.49	32.3	0.310E+01	0.49	2.99
0.49	0.00	0.49	32.3	0.310E+01	0.49	2.98
0.55	0.00	0.49	32.3	0.310E+01	0.49	2.97
0.61	0.00	0.49	32.3	0.310E+01	0.49	2.97
0.67	0.00	0.49	32.3	0.310E+01	0.49	2.96
0.73	0.00	0.49	32.3	0.310E+01	0.49	2.96
0.79	0.00	0.49	32.3	0.310E+01	0.49	2.95
0.85	0.00	0.49	32.3	0.310E+01	0.49	2.95
0.91	0.00	0.49	32.3	0.310E+01	0.49	2.94

0.98	0.00	0.49	32.3	0.310E+01	0.49	2.94
1.04	0.00	0.49	32.3	0.310E+01	0.49	2.93
1.10	0.00	0.49	32.3	0.310E+01	0.49	2.93
1.16	0.00	0.49	32.3	0.310E+01	0.49	2.92
1.22	0.00	0.49	32.3	0.310E+01	0.49	2.92
1.28	0.00	0.49	32.3	0.310E+01	0.49	2.92
1.34	0.00	0.49	32.3	0.310E+01	0.49	2.91
1.40	0.00	0.49	32.3	0.310E+01	0.49	2.91
1.46	0.00	0.49	32.3	0.310E+01	0.49	2.91
1.52	0.00	0.49	32.3	0.310E+01	0.49	2.90
1.59	0.00	0.49	32.3	0.310E+01	0.49	2.90
1.65	0.00	0.49	32.3	0.310E+01	0.49	2.90
1.71	0.00	0.49	32.3	0.310E+01	0.49	2.89
1.77	0.00	0.49	32.3	0.310E+01	0.49	2.89
1.83	0.00	0.49	32.3	0.310E+01	0.49	2.89
1.89	0.00	0.49	32.3	0.310E+01	0.49	2.89
1.95	0.00	0.49	32.3	0.310E+01	0.49	2.88
2.01	0.00	0.49	32.3	0.310E+01	0.49	2.88
2.07	0.00	0.49	32.3	0.310E+01	0.49	2.88
2.13	0.00	0.49	32.3	0.310E+01	0.49	2.88
2.20	0.00	0.49	32.3	0.310E+01	0.49	2.88
2.26	0.00	0.49	32.3	0.310E+01	0.49	2.88
2.32	0.00	0.49	32.3	0.310E+01	0.49	2.88
2.38	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.44	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.50	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.56	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.62	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.68	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.75	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.81	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.87	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.93	0.00	0.49	32.3	0.310E+01	0.49	2.87
2.99	0.00	0.49	32.3	0.310E+01	0.49	2.87
3.05	0.00	0.49	32.3	0.310E+01	0.49	2.87

END OF MOD271: ACCELERATION ZONE OF UNIDIRECTIONAL CO-FLOWING DIFFUSER

BEGIN MOD251: DIFFUSER PLUME IN CO-FLOW

PHASE 1: VERTICALLY MIXED, PHASE 2: RE-STRATIFIED

PHASE 1: THE DIFFUSER PLUME IS VERTICALLY FULLY MIXED OVER THE
ENTIRE LAYER DEPTH.
THIS FLOW REGION IS INSIGNIFICANT IN SPATIAL EXTENT AND WILL BE BY-PASSED.
END OF PHASE 1

PHASE 2: THE FLOW HAS RESTRATIFIED AT THE BEGINNING OF THIS ZONE

THIS FLOW REGION IS INSIGNIFICANT IN SPATIAL EXTENT AND WILL BE BY-PASSED.

END OF MOD251: DIFFUSER PLUME IN CO-FLOW

*** END OF HYDRODYNAMIC MIXING ZONE (HMZ) ***

THE WIDTH PREDICTIONS IN THE FOLLOWING MODULE WILL BE ADJUSTED BY A FACTOR
OF 1.13 IN ORDER TO SATISFY MASS FLUX CONSERVATION IN THE FAR-FIELD.

BEGIN MOD241: BUOYANT AMBIENT SPREADING

DISCHARGE IS NON-BUOYANT OR WEAKLY BUOYANT.
THEREFORE BUOYANT SPREADING REGIME IS ABSENT.

END OF MOD241: BUOYANT AMBIENT SPREADING

DUE TO THE ATTACHMENT OR PROXIMITY OF THE PLUME TO THE BOTTOM, THE BOTTOM
COORDINATE FOR THE FAR-FIELD IS DIFFERENT FROM THE AMBIENT DEPTH, ZFB = 0 m
IN A SUBSEQUENT ANALYSIS SET THE DEPTH AT DISCHARGE EQUAL TO THE AMBIENT DEPTH.

BEGIN MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

VERTICAL DIFFUSIVITY OF AMBIENT FLOW: EDIFFV = 0.012184 m**2/s
HORIZONTAL DIFFUSIVITY OF AMBIENT FLOW: EDIFFH = 0.030459 m**2/s

PROFILE DEFINITIONS:
BV = Gaussian s.d. (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d. (46%) half-width, measured horizontally in y-direction,
C = centerline concentration
S = corresponding centerline dilution
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)

PREDICTION: STAGE 1: NOT BANK ATTACHED

X	Y	Z	S	C	BV	BH	ZU	ZL
3.05	0.00	0.00	32.3	0.310E+01	0.49	3.26	0.49	0.11

PLUME INTERACTS WITH SURFACE
THE PASSIVE DIFFUSION PLUME BECOMES VERTICALLY FULLY MIXED WITHIN THIS
PREDICTION INTERVAL.

X	Y	Z	S	C	BV	BH	ZU	ZL
31.12	0.00	0.00	29.1	0.343E+01	0.38	3.79	0.38	0.11
59.19	0.00	0.00	32.7	0.306E+01	0.38	4.25	0.38	0.11
87.27	0.00	0.00	35.9	0.278E+01	0.38	4.67	0.38	0.11
115.34	0.00	0.00	38.9	0.257E+01	0.38	5.05	0.38	0.11
143.41	0.00	0.00	41.6	0.240E+01	0.38	5.41	0.38	0.11
171.48	0.00	0.00	44.2	0.226E+01	0.38	5.75	0.38	0.11
199.56	0.00	0.00	46.7	0.214E+01	0.38	6.06	0.38	0.11
227.63	0.00	0.00	49.0	0.204E+01	0.38	6.36	0.38	0.11
255.70	0.00	0.00	51.2	0.195E+01	0.38	6.65	0.38	0.11
283.77	0.00	0.00	53.3	0.188E+01	0.38	6.93	0.38	0.11
311.84	0.00	0.00	55.3	0.181E+01	0.38	7.19	0.38	0.11
339.92	0.00	0.00	57.3	0.175E+01	0.38	7.45	0.38	0.11
367.99	0.00	0.00	59.2	0.169E+01	0.38	7.69	0.38	0.11
396.06	0.00	0.00	61.0	0.164E+01	0.38	7.93	0.38	0.11
424.13	0.00	0.00	62.8	0.159E+01	0.38	8.16	0.38	0.11
452.20	0.00	0.00	64.6	0.155E+01	0.38	8.39	0.38	0.11
480.28	0.00	0.00	66.3	0.151E+01	0.38	8.61	0.38	0.11
508.35	0.00	0.00	67.9	0.147E+01	0.38	8.82	0.38	0.11
536.42	0.00	0.00	69.5	0.144E+01	0.38	9.03	0.38	0.11
564.49	0.00	0.00	71.1	0.141E+01	0.38	9.24	0.38	0.11
592.57	0.00	0.00	72.6	0.138E+01	0.38	9.44	0.38	0.11
620.64	0.00	0.00	74.1	0.135E+01	0.38	9.63	0.38	0.11
648.71	0.00	0.00	75.6	0.132E+01	0.38	9.82	0.38	0.11
676.78	0.00	0.00	77.1	0.130E+01	0.38	10.01	0.38	0.11
704.85	0.00	0.00	78.5	0.127E+01	0.38	10.20	0.38	0.11
732.93	0.00	0.00	79.9	0.125E+01	0.38	10.38	0.38	0.11
761.00	0.00	0.00	81.3	0.123E+01	0.38	10.56	0.38	0.11
789.07	0.00	0.00	82.6	0.121E+01	0.38	10.73	0.38	0.11
817.14	0.00	0.00	83.9	0.119E+01	0.38	10.91	0.38	0.11

845.21	0.00	0.00	85.2	0.117E+01	0.38	11.08	0.38	0.11
873.29	0.00	0.00	86.5	0.116E+01	0.38	11.24	0.38	0.11
901.36	0.00	0.00	87.8	0.114E+01	0.38	11.41	0.38	0.11
929.43	0.00	0.00	89.1	0.112E+01	0.38	11.57	0.38	0.11
957.50	0.00	0.00	90.3	0.111E+01	0.38	11.73	0.38	0.11
985.58	0.00	0.00	91.5	0.109E+01	0.38	11.89	0.38	0.11
1013.65	0.00	0.00	92.7	0.108E+01	0.38	12.05	0.38	0.11
1041.72	0.00	0.00	93.9	0.107E+01	0.38	12.20	0.38	0.11
1069.79	0.00	0.00	95.1	0.105E+01	0.38	12.35	0.38	0.11
1097.86	0.00	0.00	96.2	0.104E+01	0.38	12.50	0.38	0.11
1125.94	0.00	0.00	97.4	0.103E+01	0.38	12.65	0.38	0.11
1154.01	0.00	0.00	98.5	0.102E+01	0.38	12.80	0.38	0.11
1182.08	0.00	0.00	99.6	0.100E+01	0.38	12.94	0.38	0.11
1210.15	0.00	0.00	100.7	0.993E+00	0.38	13.09	0.38	0.11
1238.22	0.00	0.00	101.8	0.982E+00	0.38	13.23	0.38	0.11
1266.30	0.00	0.00	102.9	0.972E+00	0.38	13.37	0.38	0.11
1294.37	0.00	0.00	104.0	0.962E+00	0.38	13.51	0.38	0.11
1322.44	0.00	0.00	105.0	0.952E+00	0.38	13.65	0.38	0.11
1350.51	0.00	0.00	106.1	0.943E+00	0.38	13.78	0.38	0.11
1378.59	0.00	0.00	107.1	0.934E+00	0.38	13.92	0.38	0.11
1406.66	0.00	0.00	108.1	0.925E+00	0.38	14.05	0.38	0.11

SIMULATION LIMIT BASED ON MAXIMUM SPECIFIED DISTANCE = 1500.00 m
THIS IS THE REGION OF INTEREST LIMITATION.

PROFILE DEFINITIONS:
BV = Gaussian s.d. (46%) thickness, measured vertically
= or equal to layer depth, if fully mixed
BH = Gaussian s.d. (46%) half-width, measured horizontally in y-direction
C = centerline concentration
S = corresponding centerline dilution
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)

PREDICTION: STAGE 2: BANK ATTACHED

X	Y	Z	S	C	BV	BH	ZU	ZL
1406.66	14.05	0.00	108.1	0.925E+00	0.38	28.10	0.38	0.11
1408.52	14.05	0.00	108.2	0.925E+00	0.38	28.10	0.38	0.11
1410.39	14.05	0.00	108.2	0.924E+00	0.38	28.11	0.38	0.11
1412.26	14.05	0.00	108.2	0.924E+00	0.38	28.11	0.38	0.11
1414.12	14.05	0.00	108.2	0.924E+00	0.38	28.12	0.38	0.11
1415.99	14.05	0.00	108.2	0.924E+00	0.38	28.12	0.38	0.11
1417.86	14.05	0.00	108.2	0.924E+00	0.38	28.13	0.38	0.11
1419.73	14.05	0.00	108.3	0.924E+00	0.38	28.13	0.38	0.11
1421.59	14.05	0.00	108.3	0.924E+00	0.38	28.14	0.38	0.11
1423.46	14.05	0.00	108.3	0.923E+00	0.38	28.14	0.38	0.11
1425.33	14.05	0.00	108.3	0.923E+00	0.38	28.14	0.38	0.11
1427.19	14.05	0.00	108.3	0.923E+00	0.38	28.15	0.38	0.11
1429.06	14.05	0.00	108.3	0.923E+00	0.38	28.15	0.38	0.11
1430.93	14.05	0.00	108.4	0.923E+00	0.38	28.16	0.38	0.11
1432.79	14.05	0.00	108.4	0.923E+00	0.38	28.16	0.38	0.11
1434.66	14.05	0.00	108.4	0.923E+00	0.38	28.17	0.38	0.11
1436.53	14.05	0.00	108.4	0.922E+00	0.38	28.17	0.38	0.11
1438.39	14.05	0.00	108.4	0.922E+00	0.38	28.18	0.38	0.11
1440.26	14.05	0.00	108.4	0.922E+00	0.38	28.18	0.38	0.11
1442.13	14.05	0.00	108.5	0.922E+00	0.38	28.18	0.38	0.11
1443.99	14.05	0.00	108.5	0.922E+00	0.38	28.19	0.38	0.11
1445.86	14.05	0.00	108.5	0.922E+00	0.38	28.19	0.38	0.11
1447.73	14.05	0.00	108.5	0.922E+00	0.38	28.20	0.38	0.11
1449.59	14.05	0.00	108.5	0.921E+00	0.38	28.20	0.38	0.11
1451.46	14.05	0.00	108.5	0.921E+00	0.38	28.21	0.38	0.11

1453.33	14.05	0.00	108.6	0.921E+00	0.38	28.21	0.38	0.11
1455.19	14.05	0.00	108.6	0.921E+00	0.38	28.21	0.38	0.11
1457.06	14.05	0.00	108.6	0.921E+00	0.38	28.22	0.38	0.11
1458.93	14.05	0.00	108.6	0.921E+00	0.38	28.22	0.38	0.11
1460.80	14.05	0.00	108.6	0.921E+00	0.38	28.23	0.38	0.11
1462.66	14.05	0.00	108.6	0.920E+00	0.38	28.23	0.38	0.11
1464.53	14.05	0.00	108.7	0.920E+00	0.38	28.24	0.38	0.11
1466.40	14.05	0.00	108.7	0.920E+00	0.38	28.24	0.38	0.11
1468.26	14.05	0.00	108.7	0.920E+00	0.38	28.25	0.38	0.11
1470.13	14.05	0.00	108.7	0.920E+00	0.38	28.25	0.38	0.11
1472.00	14.05	0.00	108.7	0.920E+00	0.38	28.25	0.38	0.11
1473.86	14.05	0.00	108.7	0.920E+00	0.38	28.26	0.38	0.11
1475.73	14.05	0.00	108.8	0.919E+00	0.38	28.26	0.38	0.11
1477.60	14.05	0.00	108.8	0.919E+00	0.38	28.27	0.38	0.11
1479.46	14.05	0.00	108.8	0.919E+00	0.38	28.27	0.38	0.11
1481.33	14.05	0.00	108.8	0.919E+00	0.38	28.28	0.38	0.11
1483.20	14.05	0.00	108.8	0.919E+00	0.38	28.28	0.38	0.11
1485.06	14.05	0.00	108.8	0.919E+00	0.38	28.29	0.38	0.11
1486.93	14.05	0.00	108.9	0.919E+00	0.38	28.29	0.38	0.11
1488.80	14.05	0.00	108.9	0.918E+00	0.38	28.29	0.38	0.11
1490.66	14.05	0.00	108.9	0.918E+00	0.38	28.30	0.38	0.11
1492.53	14.05	0.00	108.9	0.918E+00	0.38	28.30	0.38	0.11
1494.40	14.05	0.00	108.9	0.918E+00	0.38	28.31	0.38	0.11
1496.26	14.05	0.00	108.9	0.918E+00	0.38	28.31	0.38	0.11
1498.13	14.05	0.00	109.0	0.918E+00	0.38	28.32	0.38	0.11

SIMULATION LIMIT AS SPECIFIED HAS BEEN REACHED; PREDICTION TERMINATES
AT THIS STAGE.

1500.00	14.05	0.00	109.0	0.918E+00	0.38	28.32	0.38	0.11

END OF MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

BECAUSE OF THE FAIRLY LARGE SPACING BETWEEN ADJACENT RISERS/NOZZLES/PORTS,
THE ABOVE RESULTS MAY BE UNRELABLE IN THE IMMEDIATE NEAR-FIELD OF
THE DIFFUSER.
A SUBSEQUENT APPLICATION OF CORMIX1 IS RECOMMENDED TO PROVIDE MORE DETAIL
FOR ONE OF THE INDIVIDUAL JETS/PLUMES IN THE INITIAL REGION
BEFORE MERGING.

End of Output
CORMIX2: Submerged Multiport Diffusers   EPA Version 1.30 (February 1992)

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APPENDIX B
Calculation of Minimum Head Required for Proper Diffuser Operation

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Diffuser Design
Rawn et al.'s method

Assumptions

2.5	*Qavg, cfs*
4	*Qdesign, cfs*
20	*Length, feet*
0.04	*Slope, ft/ft*
5	*No. of ports*
62.4	*Ambient lbs/cu.ft.*
62.4	*Effluent lbs/cu.ft.*
0.015	*Darcy-Weisbach friction*
200	*Available head, feet*
12	*Manifold diameter, inches*

Step 1. Fill in assumptions column.
Step 2. Change table to appropriate number of ports.
Step 3. Use approx. port dia. for initial conditions in table.
Step 4. Vary downstream head until total discharge is equal to Qdesign.
Step 5. Change port diameters for uniform port discharges and for desired head loss.
Step 6. Goto step 4 until satisfactory results.

Results

5.00	*spacing, feet*
0.80	*cfs/port*
0.629	*discharge coefficient*
1.43	*approx. dia. of ports, inches*

port no.	*diffuser diameter inches*	*port diameter inches*	*head ft*	*Cd*	*port discharge cfs*	*cum.port discharge cfs*	*port velocity fps*	*diffuser velocity fps*
1	12	3	10.55	0.63	0.81	0.81	16.42	1.03
2	12	3	10.55	0.629	0.80	1.61	16.40	2.05
3	12	3	10.56	0.626	0.80	2.41	16.33	3.07
4	12	3	10.57	0.622	0.80	3.21	16.22	4.09
5	12	3	10.59	0.616	0.79	4.00	16.08	5.09

Notes:
1. All shaded numbers are for input.
2. Positive slope is downward to end of diffuser.
3. Port diameter must be < 1/4 pipe diameter and < 1/10 port spacing.
4. Downstream port is port number 1.

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Diffuser Design
Rawn et al.'s method

Assumptions

2.5	*Qavg, cfs*
2.5	*Qdesign, cfs*
20	*Length, feet*
0.04	*Slope, ft/ft*
5	*No. of ports*
62.4	*Ambient lbs/cu.ft.*
62.4	*Effluent lbs/cu.ft.*
0.017	*Darcy-Weisbach friction*
200	*Available head, feet*
12	*Manifold diameter, inches*

Step 1. Fill in assumptions column.
Step 2. Change table to appropriate number of ports.
Step 3. Use approx. port dia. for initial conditions in table.
Step 4. Vary downstream head until total discharge is equal to Qdesign.
Step 5. Change port diameters for uniform port discharges and for desired head loss.
Step 6. Goto step 4 until satisfactory results.

Results

5.00	*spacing, feet*
0.50	*cfs/port*
0.630	*discharge coefficient*
1.13	*approx. dia. of ports, inches*

port no.	*diffuser diameter inches*	*port diameter inches*	*head ft*	*Cd*	*port discharge cfs*	*cum.port discharge cfs*	*port velocity fps*	*diffuser velocity fps*
1	12	3	4.13	0.63	0.50	0.50	10.27	0.64
2	12	3	4.13	0.629	0.50	1.01	10.26	1.28
3	12	3	4.13	0.626	0.50	1.51	10.22	1.92
4	12	3	4.14	0.622	0.50	2.01	10.15	2.56
5	12	3	4.15	0.616	0.49	2.50	10.06	3.19

Notes:
1. All shaded numbers are for input.
2. Positive slope is downward to end of diffuser.
3. Port diameter must be < 1/4 pipe diameter and < 1/10 port spacing.
4. Downstream port is port number 1.

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Diffuser Design

Rawn et al.'s method

Assumptions

2.5	*Qavg, cfs*
1	*Qdesign, cfs*
20	*Length, feet*
0.04	*Slope, ft/ft*
5	*No. of ports*
62.4	*Ambient lbs/cu.ft.*
62.4	*Effluent lbs/cu.ft.*
0.0201	*Darcy-Weisbach friction*
200	*Available head, feet*
12	*Manifold diameter, inches*

Step 1. Fill in assumptions column.
Step 2. Change table to appropriate number of ports.
Step 3. Use approx. port dia. for initial conditions in table.
Step 4. Vary downstream head until total discharge is equal to Qdesign.
Step 5. Change port diameters for uniform port discharges and for desired head loss.
Step 6. Goto step 4 until satisfactory results.

Results

5.00	*spacing, feet*
0.20	*cfs/port*
0.630	*discharge coefficient*
0.72	*approx. dia. of ports, inches*

port no.	*diffuser diameter inches*	*port diameter inches*	*head ft*	*Cd*	*port discharge cfs*	*cum.port discharge cfs*	*port velocity fps*	*diffuser velocity fps*
1	12	3	0.66	0.63	0.20	0.20	4.11	0.26
2	12	3	0.66	0.629	0.20	0.40	4.10	0.51
3	12	3	0.66	0.626	0.20	0.60	4.09	0.77
4	12	3	0.66	0.622	0.20	0.80	4.06	1.02
5	12	3	0.66	0.616	0.20	1.00	4.02	1.27

Notes:

1. All shaded numbers are for input.
2. Positive slope is downward to end of diffuser.
3. Port diameter must be < 1/4 pipe diameter and < 1/10 port spacing.
4. Downstream port is port number 1.

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